Variability of the Surface Circulation and temperature in the Adriatic Sea

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LONG-TERM GOALS

My long-term goals are to contribute to the understanding of the dynamics of marginal seas such as the Adriatic by collecting and interpreting observations of currents and water mass properties (e.g., temperature, salinity, chlorophyll concentration). In particular I am very interested in studying the impact of the wind forcing and fresh water runoffs on the circulation. Also of interest to me is the study of the variability of the surface velocity and temperature fields in the Adriatic at the meso-, seasonal and interannual scales.

OBJECTIVES

The first objective of this project is to assess the quality of historical drifter data sets in the Mediterranean Sea, i.e., to intercompare the water-following capabilities of the various drifters, to apply adequate corrections and to merge these data sets to obtain a useful multi-year drifter database.

The second goal is to use historical and new drifter observations, along with satellite images, to describe the spatial characteristics and the temporal variability of the surface circulation and the sea surface temperature (SST) in the global Adriatic basin, from meso- to interannual scales.

The third objective is to investigate some aspects of the response of the surface circulation and SST to atmospheric and boundary forcings. In particular, our goal is to study the characteristics of the wind-driven currents in relation to the surface wind forcing, obtained from wind measurements and from atmospheric model products.

APPROACH

The first step is to analyze and interpret historical Mediterranean surface drifter data sets collected between 1989 and 1997 by various organizations, mostly by the SACLANT Undersea Research Centre (SACLANTCEN) and by the Naval Oceanographic Office (NAVOCEANO). In order to combine the different drifter data sets a qualitative comparison study of the water-following capabilities of the drifter systems used is performed. Satellite AVHRR images archived by SACLANTCEN are processed to provide navigated and calibrated SST maps. The SACLANTCEN and NAVOCEANO drifter observations are confronted with concurrent satellite thermal images. A qualitative description of surface currents and SST using drifter trajectories superimposed on AVHRR images and a quantitative statistical comparison of satellite- and drifter-inferred SSTs are performed.

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The second step is to make new effective measurements of the surface currents and SST in the global Adriatic basin with particular attention to the seasonal variability of the circulation and to the major forcings. Releases and tracking of Lagrangian drifters are conducted to achieve this goal. Satellite imagery is used to provide additional information of the surface currents and the surface temperature fields.

WORK COMPLETED

The data from 211 drifters operated by NAVOCEANO between 1989 and 1997 were acquired in raw format. The data were quality controlled, reduced and edited for obvious outliers. The NAVOCEANO and SACLANTCEN (130 drifters, for details see Poulain, 1998; Poulain and Zanasca, 1998a; Poulain and Zanasca, 1998b) drifter databases were searched to find drifters of both types in the same area during the same time period. A few cases were found, especially in the southeastern Adriatic and in the Strait of Sicily.

More than 600 AVHRR images of the Adriatic were processed at the Satellite Oceanography Laboratory of the University of Hawaii. The images cover the period between May and November 1995. The processing included registration, navigation, calculation of SST and cloud masking. The SST maps were made available on a CD-ROM that will be distributed to the oceanographic community at the end of the year.

A total of 63 modified-CODE (Poulain, 1998) drifters and 3 GDP/MINIMET (SVP-8, 1996) drifters were successfully deployed between 22 August and 22 September 1998 by colleagues of the Osservatorio Geofisico Sperimentale, Trieste (OGS) and other Italian and Croatian institutes. In-situ wind observations were made following the release of the GDP/MINIMET drifters for wind calibration purposes.

The drifter data have been downloaded from Service Argos on a daily basis. After some pre-processing and data reduction, graphical representations of the drifter statistics, of the drifter trajectories and the temperature time series, etc. have been produced and updated every day in a dedicated world wide web page (NPS, 1998). The data were also quality controlled, reduced and edited for obvious outliers. They were then added to the drifter database. All the edited drifter data were low-pass filtered (36 hour cut-off) and uniformly interpolated at 6-hour intervals. Drifter velocities were estimated by finite differencing the position data.

RESULTS

A statistical comparison between contemporaneous surface temperature data from drifters and from satellite images provided satisfactory results. The SST images were analyzed to provide image composites over 3-day, weekly and monthly periods. A qualitative description of the surface mesoscale structures in the Adriatic and of their associated temporal variability was done by superimposing drifter trajectory segments on the satellite images. As an example, three images are depicted in Fig. 1. Most of the time, there is a remarkable agreement between the drifter motions and the structure and evolution of the SST features.

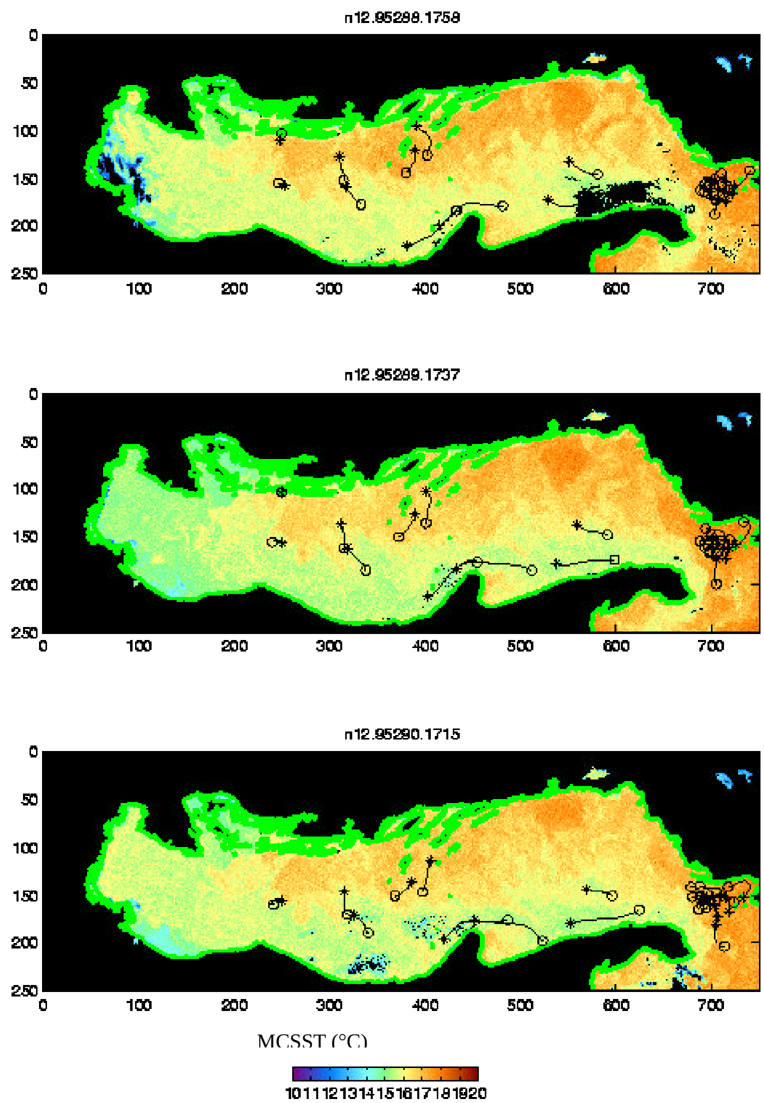

Fig. 1. Color-coded SST images of the Adriatic on 12 (top), 13 (middle) and 14 (lower) October 1995 between 1700 and 1800 GMT. Drifter trajectories are overlaid in black for the day of the image and for the two preceding days. Star and circle symbols denote first and last positions, respectively.

The drifter trajectories in the Adriatic between 1990 and 1998 were plotted by years and by seasons. Despite the non-uniform sampling over the seasons and years, significant variabilities at meso-, seasonal and interannual scales are evident, the later two being forced at the air-sea (momentum and heat fluxes) and lateral (river and strait transports) boundaries . I then focused on the period between August 1997 and October 1998 when the drifter population is relatively high and more uniformly distributed (both in time and space). Fig. 2 depicts the smoothed drifter trajectories for that period. It is obvious that our deployment strategy was successful at covering most of the Adriatic. The Western Adriatic Current (WAC) along the Italian Peninsula and the gyre circulations in the central and southern basins are apparent in the composite track plot.

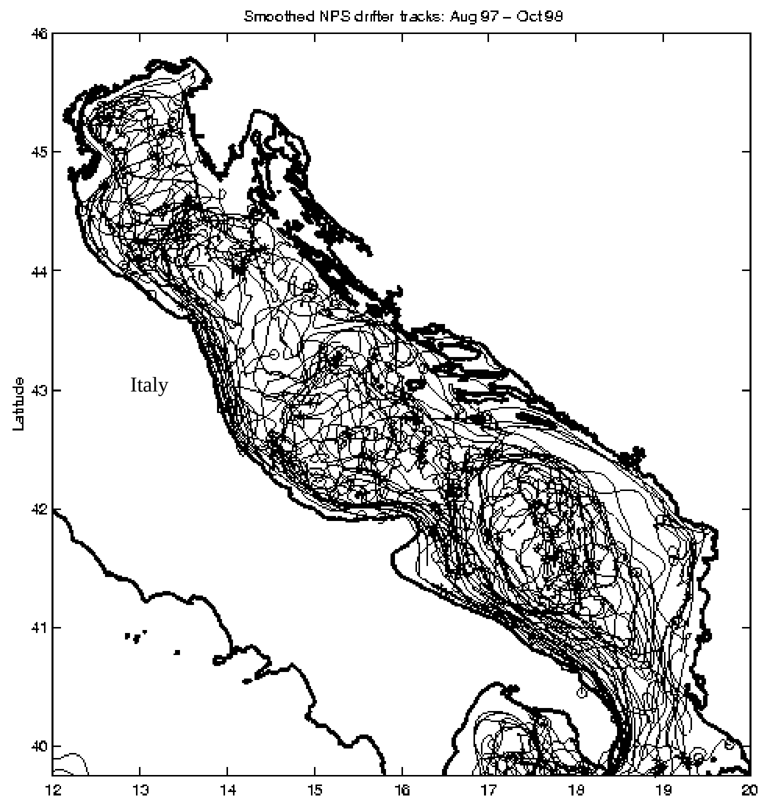

Fig. 2. Low-pass filtered drifter trajectories between August 1997 and October 1998.

A simple way to create maps of mean currents and velocity variability is to average the drifter velocities in 0.25°x0.25° boxes. These statistics are presented in Fig. 3. The WAC along the Italian coast and the eastern coastal current in the central and southern basins are associated with the strongest mean currents (reaching 30-40 cm s^{-1}) and the largest velocity variance (up to 500 cm^2 s^{-2}). The mean currents are generaly weak in the center of the central and southern gyres and in the northern region. Seasonal and eddy variability is small in the centre of the southern gyre whereas it is significant in the central and northwestern regions.

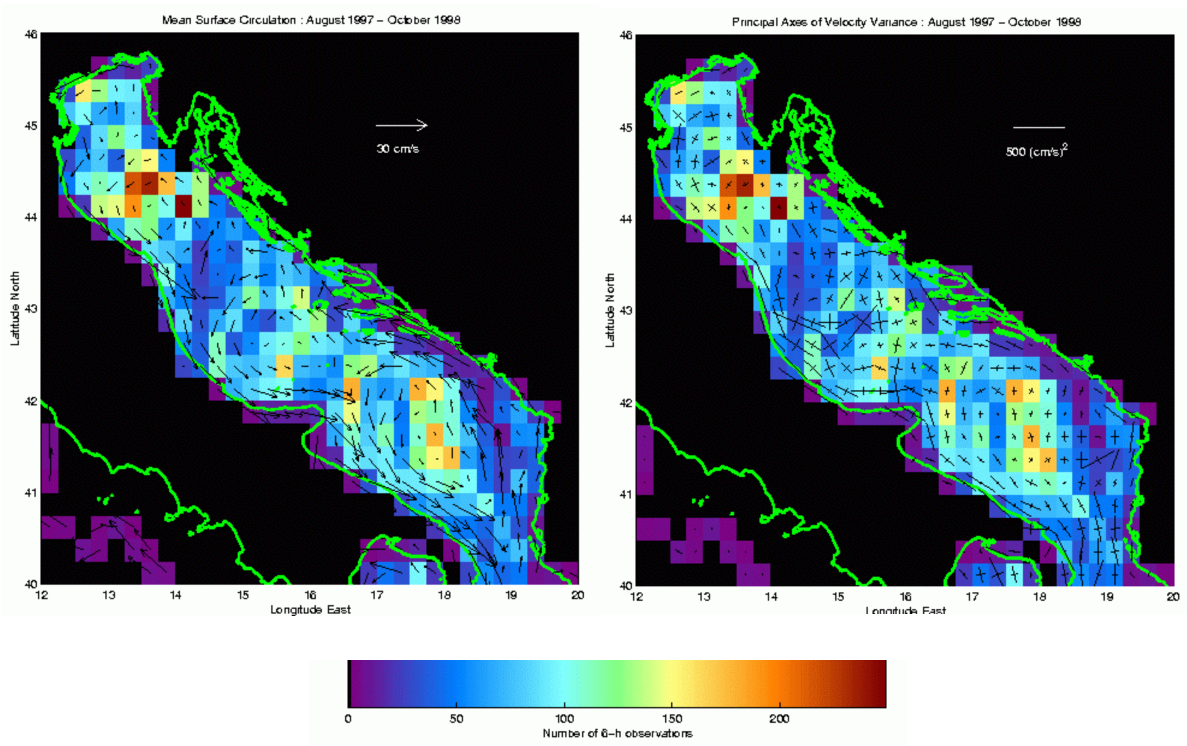

Fig. 3. Maps of mean surface circulation (left) and principal axes of velocity variance (right) as derived from the drifter data between August 1997 and October 1998. The numbers of 6-hourly observations are color coded.

IMPACT/APPLICATION

The scientific impact of this project will be to increase our understanding of the Adriatic Sea dynamics and of the major forcing mechanisms. Future application could be the assimilation of the drifter data into numerical models in the framework of the anticipated Mediterranean Forecasting System.

TRANSITIONS

Graphical representations of the drifter data are made available on the world wide web (NPS, 1998) in quasi-real time. Anyone interested in the Mediterranean surface currents and temperature, in particular for rescue, military and fisheries operations can use this information.

The drifter SST data are directly distributed onto the Global Telecommunication System (GTS), a network operated by National Meteorological Services to exchange data on a global basis. In this way, the drifter SSTs are directly used and assimilated into models for weather forecasting.

The drifter data will be used by European scientists working on the deep-water formation mechanisms in the southern Adriatic as part of the MATER program (MATER, 1998).

This program proves the usefulness of the drifters that NAVOCEANO has been (and is currently) using to obtain environmental observations during sea operations, to quantitatively estimate surface currents. It is planned to assimilate the drifter data (velocities and SST) into Navy operational numerical models of the circulation in the Adriatic to improve forecasting skills.

RELATED PROJECTS

Italian PRISMA Project: Hydrographic surveys in the western Adriatic and HF radar observations off Ancona, Italy, as part of the Italian project "Programma di RIcerca e Sperimentazione per il Mare Adriatico" (PRISMA-2a) are closely related to this project.

MATER Project: Surveys in the southern Adriatic and Strait of Otranto (MATER, 1998) to study the mechanisms of formation and spreading of deep Adriatic water have been used to deploy the majority of the drifters of our ONR project. Most of the hydrographic and drifter data will be shared and joint publications will be written.

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